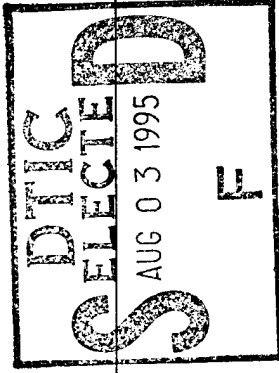




TTC-2583-V  
7 December 1992  
Copy No. **3**



## Gated Blue Cesium Faraday Atomic Line Filter

**Lasers '92, Houston  
8 December 1992**

**Prepared by:**

Jim Menders, Paul Searcy, David Ross, Eric Korevaar  
ThermoTrex Corporation, San Diego, CA

Bill Scharpf  
Naval Air Warfare Center, Warminster, PA

David Allocca  
Ampac, Inc., Warminster, PA

With thanks to:  
Craig Howton, ThermoTrex Corporation

This work was sponsored by the Naval Air Warfare Center  
Under Contract N62269-90-C-0516

**DISTRIBUTION STATEMENT A**

Approved for public release  
Distribution Unlimited

19950802 029

DTIC QUALITY INSPECTED 5

**TTC**

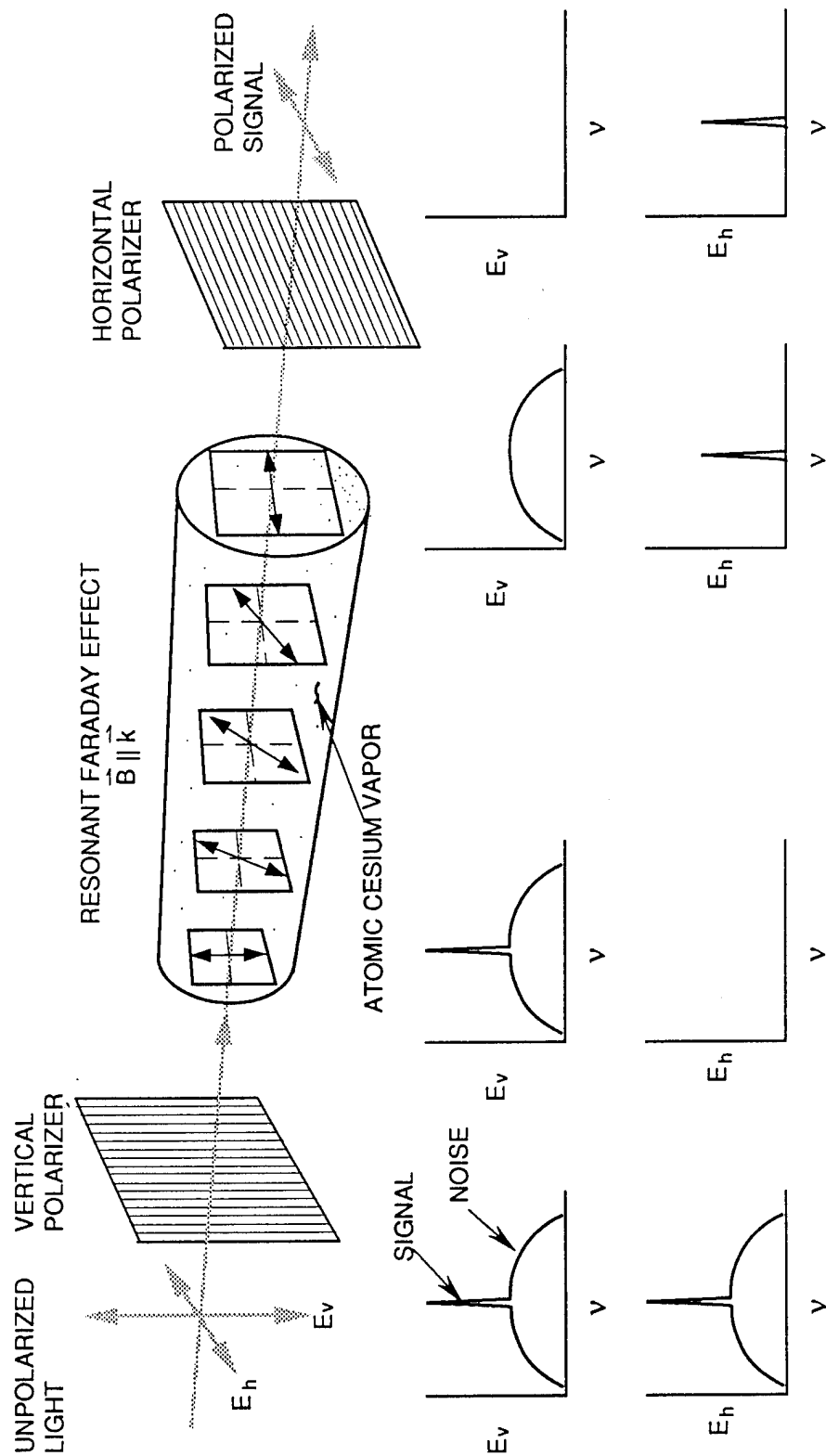
## GATED ULTRA-NARROW MAGNETO-OPTIC ATOMIC LINE FILTERS FOR LIDAR APPLICATIONS

- Solar background limited lidar receivers require ultra-narrow linewidth filters to reach quantum limited operation
  - remote sensing
  - active tracking
- Like the conventional absorptive/re-emissive atomic line filters (ALF), the M-0 ALFs
  - operate at discrete atomic absorption lines
  - have Doppler limited passbands
  - high out-of-band rejection
- However, M-0 ALFs are imaging filters with
  - very high peak transmission
  - wide field-of-view
  - filter bandwidth limited signal bandwidth
- Dynamic range limited receivers benefit from programmable gain to suppress unwanted signals from nearby sources
  - the gated M-0 ALF transmission can be stepped or ramped to reject early signals

Accession For	
NTIS	CRA&I <input checked="" type="checkbox"/>
DTIC	TAB <input type="checkbox"/>
Unannounced	<input type="checkbox"/>
Justification	
By	<i>Reg. lti</i>
Distribution	
Availability Codes	
Dist	Avail and/or Special
A-1	

- Principles of Faraday magneto-optic filter operation
- Transmission modulation by field intensity modulation
- Optimizing operating temperature for low field, high transmission
- Pulsed coil design for large (2"  $\phi$ ) aperture filter
- Gated filter tests
- Conclusion

## PRINCIPLES OF FARADAY MAGNETO-OPTIC ATOMIC LINE FILTER OPERATION

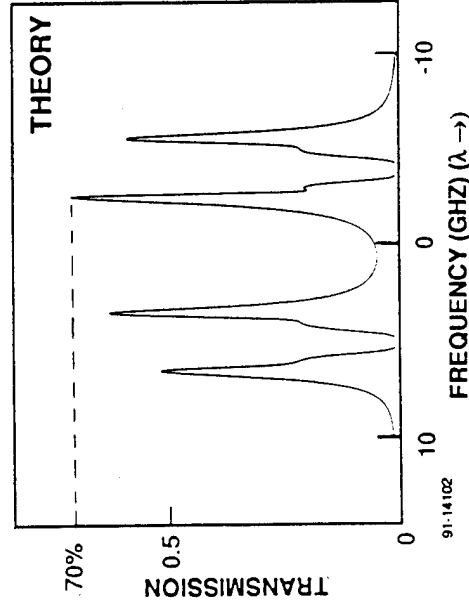
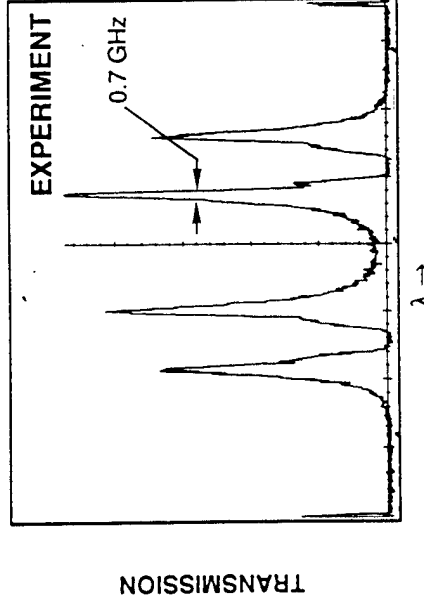


- The magneto-optic element transforms vertical into horizontal polarization over a narrow spectral band
- The resonant Faraday effect is exhibited in near strong absorption lines
- In-band light is transmitted; out-of-band light is blocked
- This work concerns the cesium Faraday filters with resonances at 455 nm and 852 nm

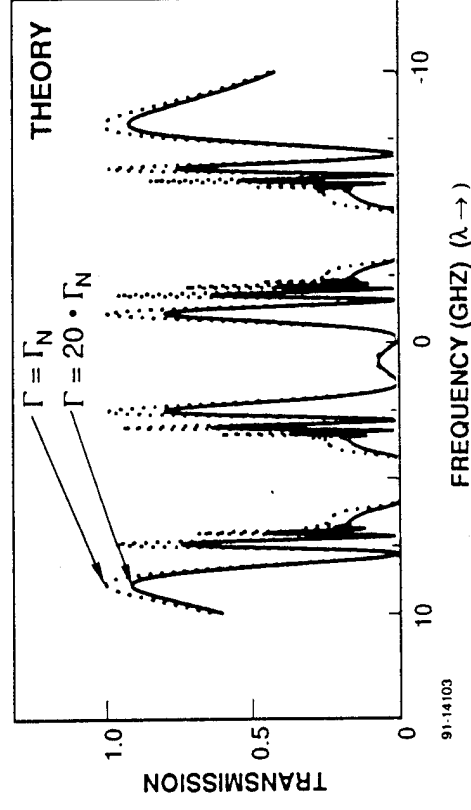
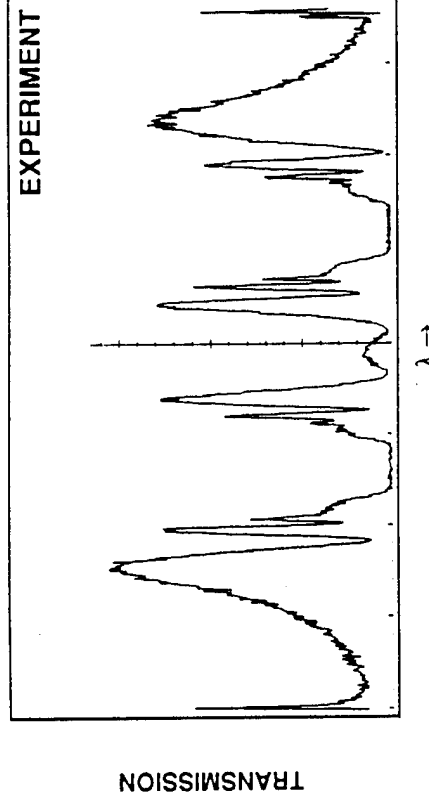


## BLUE FARADAY FILTER SPECTRA ARE WELL PREDICTED UP TO 200° C

140° C, 200 G, 1 in.

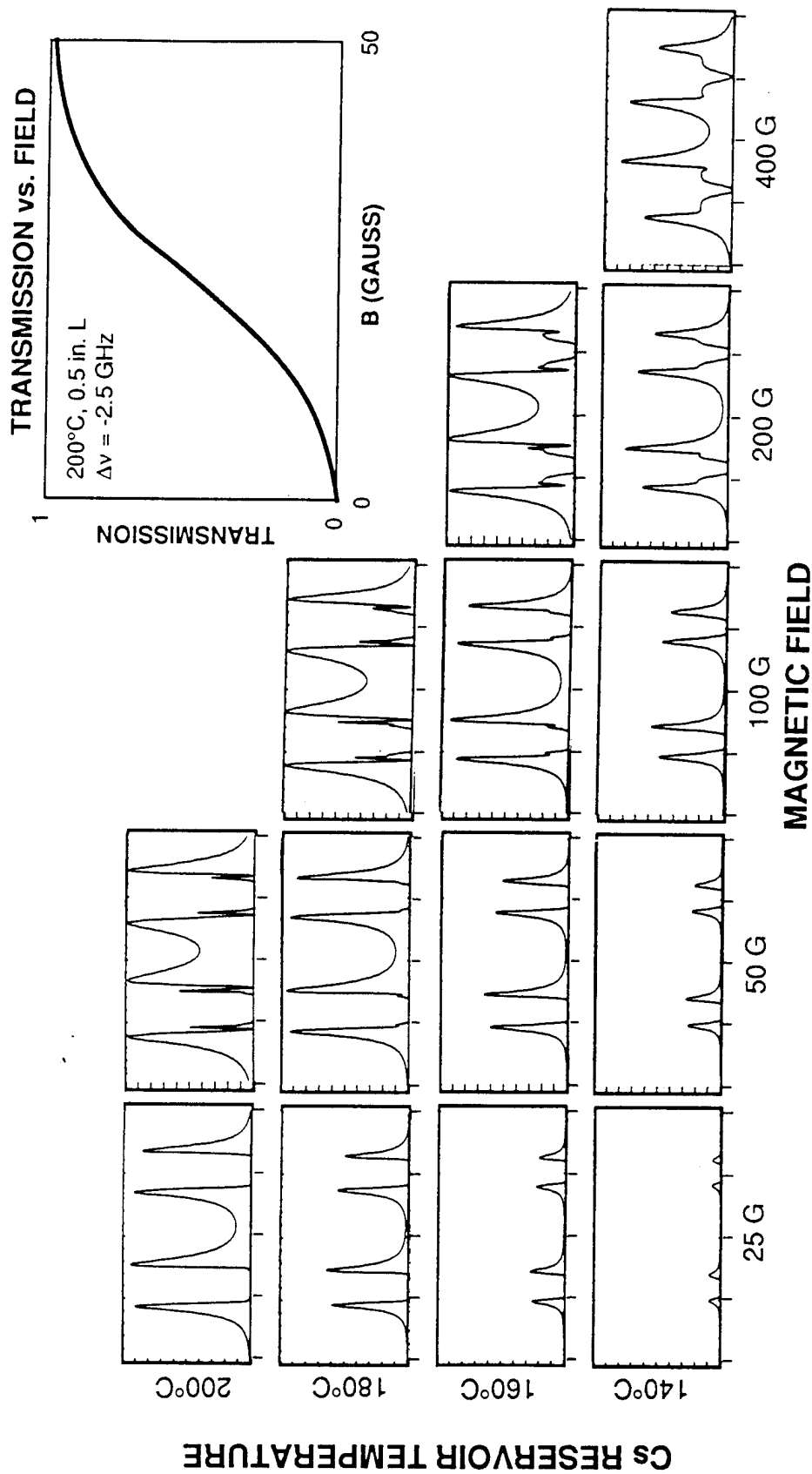


200° C, 200 G, 1 in.



- Optimum conditions minimize bandwidth and maximize transmission
- Modelling above 200° C must allow for collisional broadening
- Additional broadening becomes apparent at temperature  $T \geq 200^\circ \text{C}$

## GATING IS ACCOMPLISHED BY FIELD MODULATION

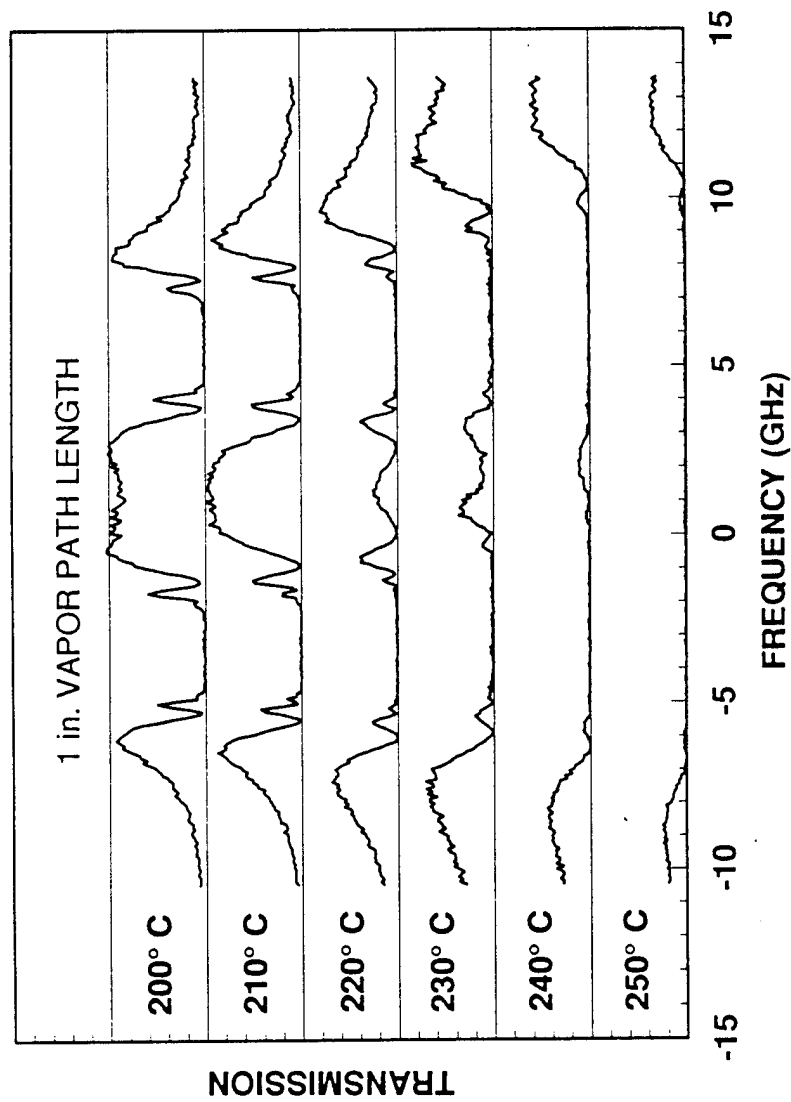


- Calculated blue Faraday filter spectra (0.5 in. L)
- Higher vapor temperatures can be traded for reductions in maximum magnetic field



## THE FIELD REDUCTION FOR TEMPERATURE TRADE IS LIMITED BY TRANSMISSION DEGRADATION

### BLUE FARADAY FILTER SPECTRA



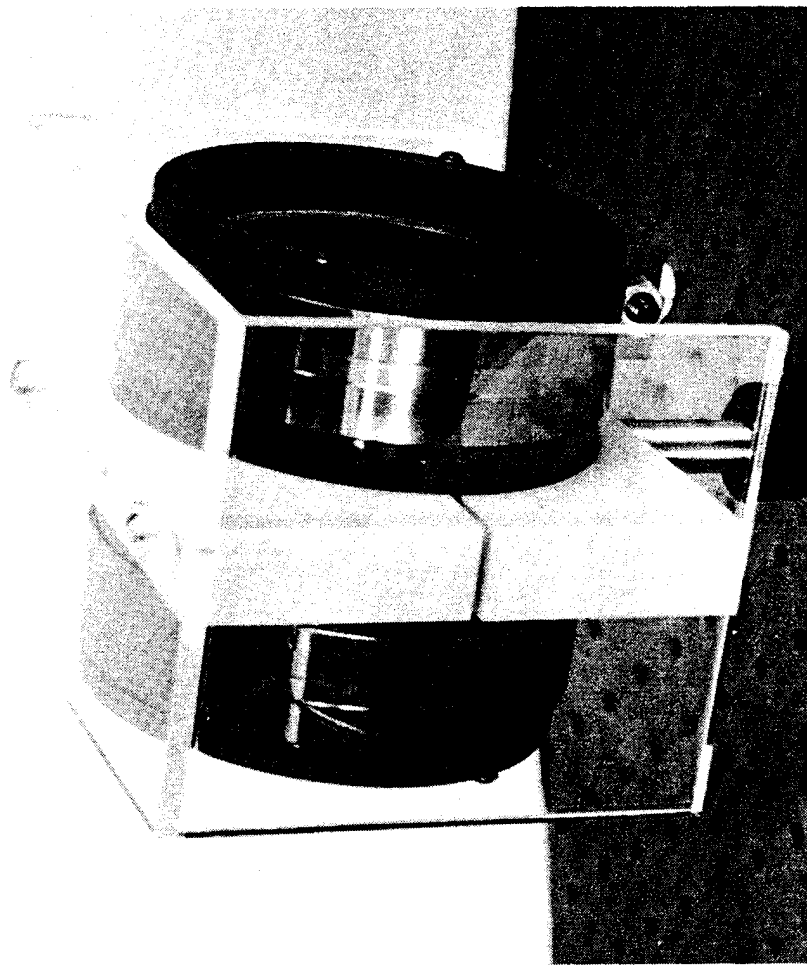
- Transmission spectra normalized by combined component transmission
- Increased collisional broadening at higher temperatures extends absorption line wings
  - Peak passband transmission is spoiled

- Requirements
  - 50 G longitudinal field
  - Uniform throughout active volume, 1 cm L x 5 cm  $\phi$  ( $\sim 2\%$ )
  - Square pulse field modulation
    - risetime: 10 s of nanoseconds
    - duration:  $\gtrsim 1 \mu\text{s}$
- Pulsed coil implementation
  - Coil
    - single loop Helmholtz-like coils
    - Strip conductors for minimum inductance ( $\sim 1/3 \mu\text{H}$ )
    - 250 amp peak current for 50 gauss
  - Current supply
    - thyatron switched pulse forming network (PFN)
    - $\sim 600 \text{ ft}$  spool of  $50 \Omega$  coax PFN
    - $< 35 \text{ kV}$  charge voltage



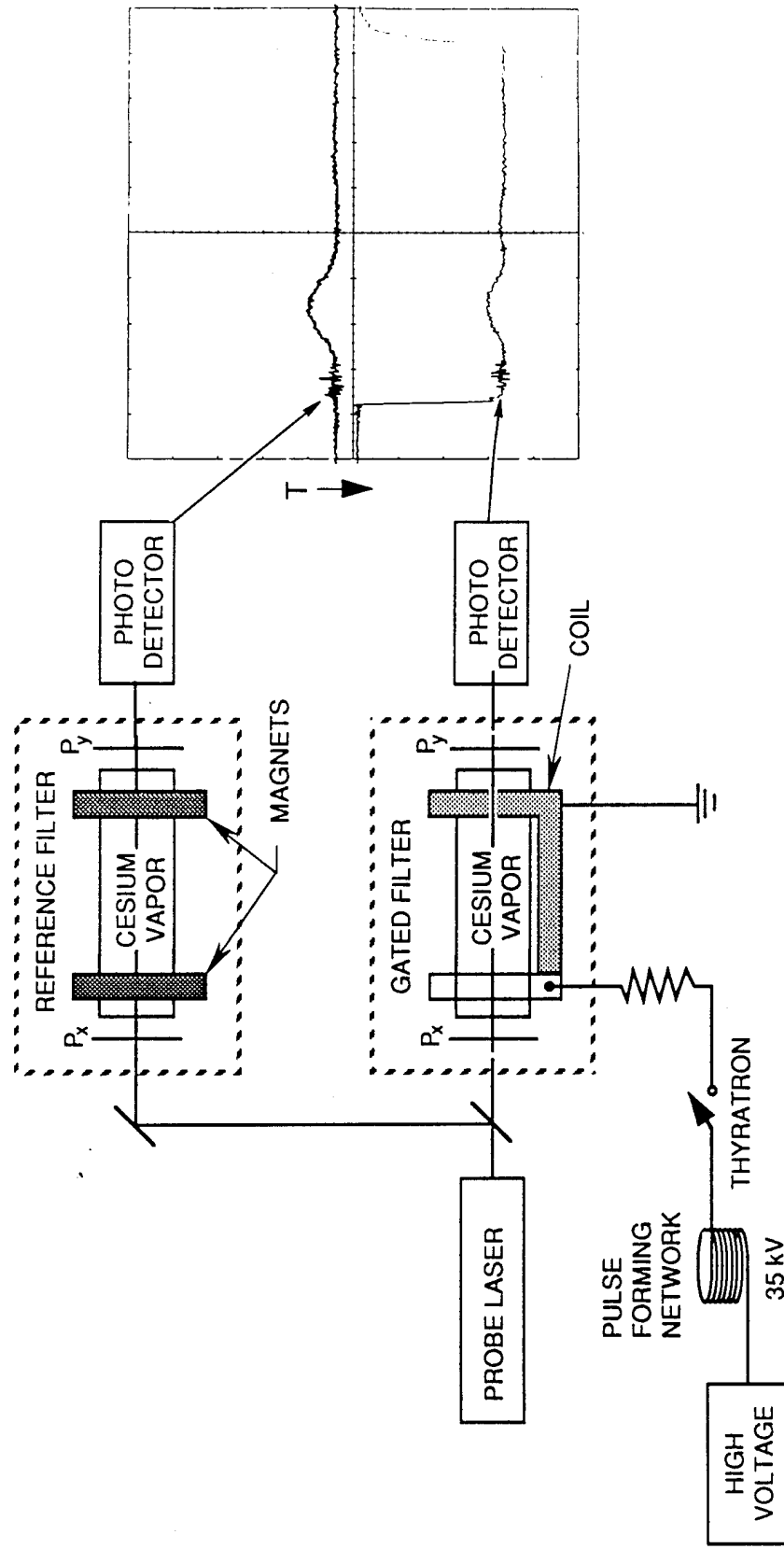


## GATED CESIUM FARADAY FILTER



- Ultra-narrow bandpasses at 455, 459, 852 and 894 nm
- Unobscured 1 in. CA at angles up to 30° (2 in. CA at normal incidence)
- Out-of-band transmission (on axis)  $\sim 10^{-5}$
- Open transmission (to polarized light) 32%

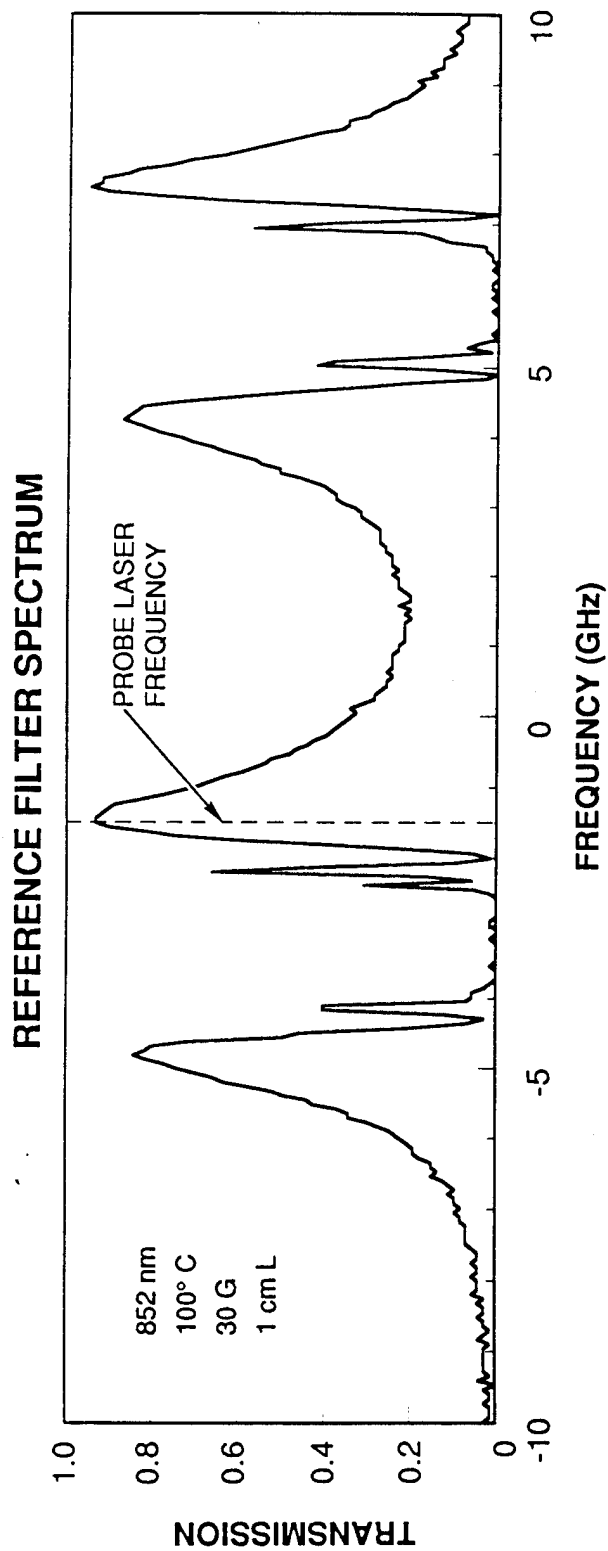
## GATED FARADAY FILTER TEST SET-UP



- Gating was demonstrated for the near IR and blue passbands
  - NIR: Single mode diode laser at 852 nm
  - Blue: Single frequency dye laser at 455 nm
- Laser frequency stability was ascertained from reference filter transmission



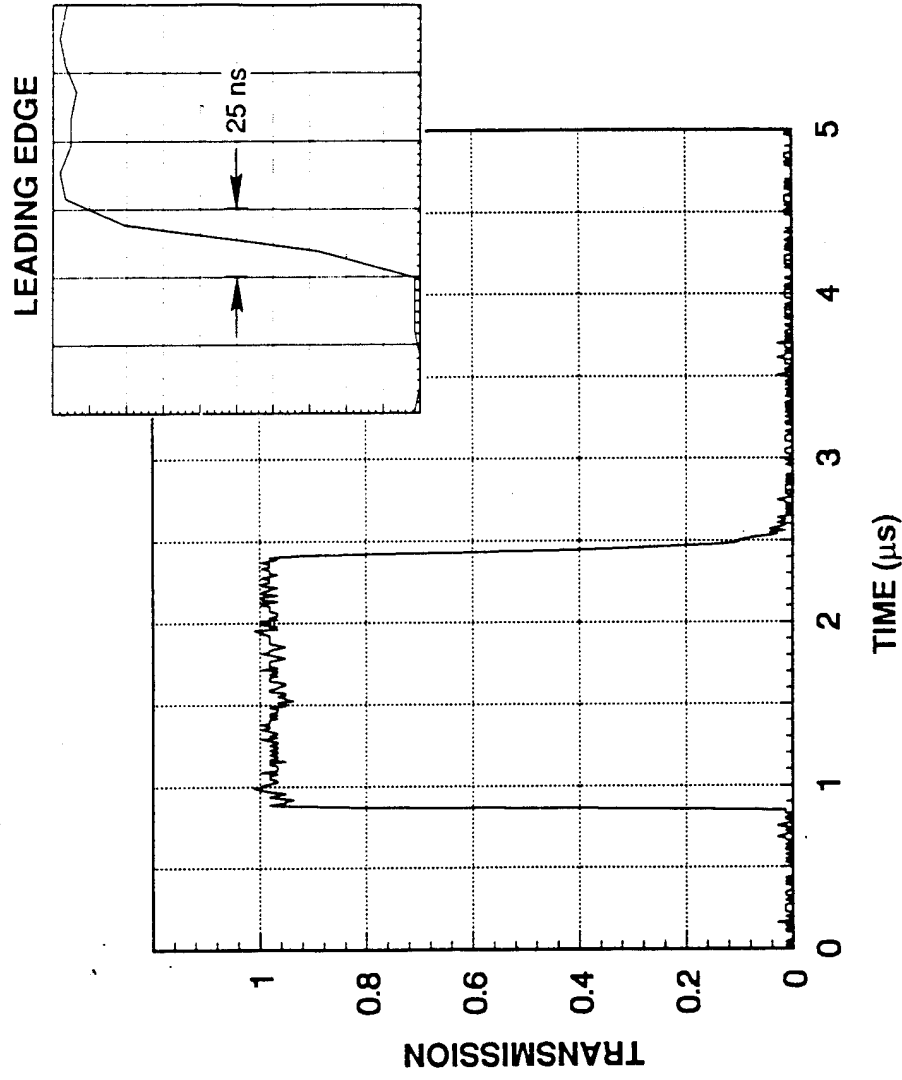
## NIR GATED FARADAY FILTER TEST CONDITIONS



- Developmental testing is easier at 852 nm
  - Single mode diode laser probe
  - Lower temperature/field operating point
- Gated blue filter testing continues at NADC
  - Single frequency blue dye laser

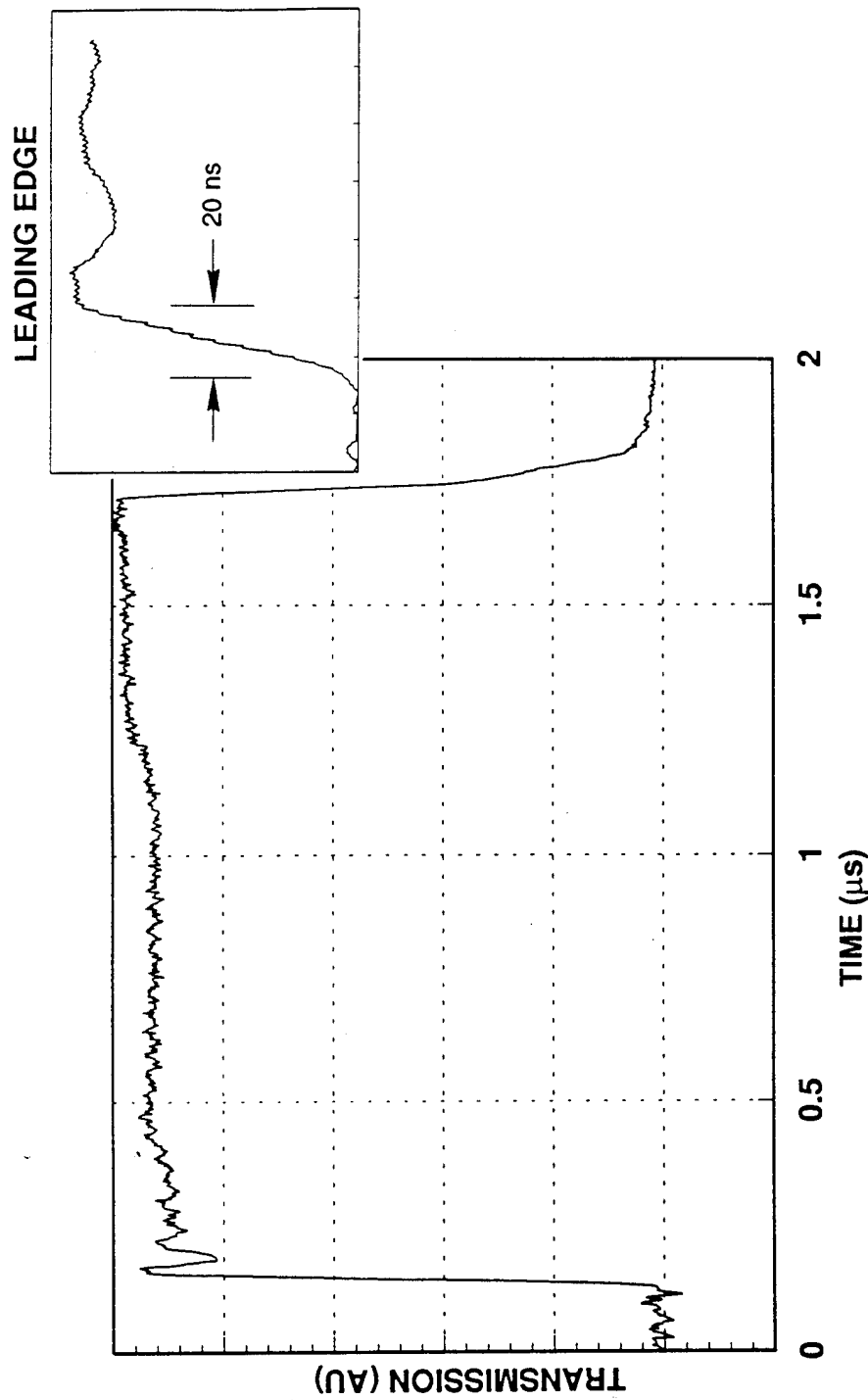


## GATED NIR FARADAY FILTER TRANSMISSION



- Transmission with respect to peak passband transmission
- The sharp 20 ns risetime can be used to discriminate against nearby scattering

## GATED BLUE FARADAY FILTER TRANSMISSION



- Replicates NIR result
- Absolute transmission measurements are in progress
- A faint blue glow, produced at high temperatures and fields, was observed and is under investigation (RF discharge?)

- The blue Cs Faraday atomic line filter was previously shown to provide ultra narrow, high transmission bandpasses with high background rejection
- The filter transmission may be modulated by varying the field, providing suppression of close range scattering
- The optimal operating vapor temperature of 200°C minimizes the field requirement while avoiding the collisionally broadened regime
- Gating tests at 852 nm and 455 nm demonstrated rapid 20-25 ns transmission risetimes in a 2" aperture, wide field-of-view filter